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Date: September 6, 2012

To: Chuck Murray, Washington State Department of Commerce

David Cohan, Northwest Energy Efficiency Alliance

From: Ben Larson and David Baylon, Ecotope Inc.

Re: Residential WSEC 2012 Energy and Cost Analysis

## **Overview and Key Assumptions**

Ecotope has completed energy and cost analyses of the residential portion of the 2012 Washington State Energy Code (WSEC). Ecotope conducted building modeling to predict the energy use of houses constructed under both the 2009 and proposed 2012 energy codes. The difference between the two constitutes the incremental energy savings of the new code. Likewise, Ecotope estimate the incremental capital costs of the energy efficiency improvements in the new code.

To conduct the analysis, Ecotope made key assumptions about which options in 2009 houses used to meet that energy code. For mid-size gas furnace and heat pump options, we asserted the houses used option 1a, the high efficiency HVAC equipment, from Table 9-1 in the 2009 WSEC. For mid-size houses that are heated with zonal electric resistance, we asserted the houses used option 3b, efficient building envelope 2. For houses less than 1500 ft<sup>2</sup> in floor area, no options are needed. Ecotope did not model the large houses greater than 5000ft<sup>2</sup> in floor area because they make up a small fraction of the overall building market.

The assumptions setting the baseline are integral to the entire analysis. All energy savings are calculated relative to those baselines in 2009. Likewise, all incremental costs are calculated to the same baseline.

## **Results**

Using a weighted combination of building sizes and HVAC systems to represent all new residential construction in the state, the analysis shows a likely range of energy savings and costs per house built including:

- Electricity saved vs 2009 for each house: 669-681 kWh/yr
- Natural gas saved vs 2009 for each house: 42-44 therms/yr
- Total site energy use reduction vs 2009: 9.6-9.8%
- Incremental first cost of: \$678-\$790

Table 1 presents the results in a more granular basis for the mid-size and small houses with three heating system types for a selected combination of option and compliance paths.

**Table 1. Selected Combinations: Energy and Costs** 

		Sav	ings vs 2009	Incremental Cost	Simple Payback	
Prototype	Heating Type	kWh/yr	therms/yr	%	\$	years
Mid-Size House	Gas Furnace	642	51	10%	\$ 768	6.6
Small House	Gastamace	679	43	12%	\$ 230	2.1
Mid-Size House	Hoot Dumn	1054	0	8%	\$ 77	0.9
Small House	Heat Pump	868	0	8%	\$ -	0.0
Small House	Elec. Res. Zonal	671	0	6%	\$ 77	1.4

Table 3 presents detailed results for a multitude of compliance paths for the 2012 code. The labeling code for Table 3 is given in Table 2. Each house size and heating system type has a different set of options available to attain the 0.5 or 1.5 points needed for code compliance. The large combination of possibilities leads to the large number of rows in Table 3. Not every possibility is presented in Table 3; however, the most likely combinations are. Further, to determine what the overall, statewide energy savings might be, Ecotope estimated the frequency with which each compliance path may occur. We created two scenarios depicted in the columns BL1 and DB1.

Table 2. Labeling Code for Table 3.

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Heating Systems						
gfnc	Gas Furnace No Cooling					
gfac	Gas Furnace with Cental Cooling					
hp77	Heat Pump HSPF 7.7					
hp85	Heat Pump HSPF 8.5					
zonl	Zonal Resistance Heat					
Code Options (Table 406.2)						
Option	Description	Credits				
1a	envelope a	0.5				
1b	envelope b	1				
1c	envelope c	2				
2a	exhaust fan	0.5				
2b	hrv b	1				
2c	hrv c	1.5				
3a	95 AFUE (gas only)	0.5				
3b	8.5 HSPF (hp only)	1				
3d	dhp (zonal only)	1				
4_	ducts inside	1				
5a	dhw low flow better tank	0.5				
5b	hpwh or gas tankless	1.5				
6_	renewables onsite	0.5				

Table 3. WSEC 2012 Energy Savings and Cost vs 2009

Size		House	Options Combinations	Savings vs 2009			lu anamantal		Options Weighting	
STORY   Cooling   Furnace No	House Size	_				Total	Incremental Cost		BL1	DB1
### Page 1			gfnc_1a_2a_5a	861	58	11.6%	\$	1,595	0.05	0.075
Section   Page   Page			gfnc_3a_1a_2a	861	51	10.7%		1,826	0.05	0.05
STATE   Cooling   Gas   Furnace No Cooling   Gas   Garne   La   La   La   La   La   La   La   L								1,313		0.125
Tage										0.25
Furnace No Cooling  Fig. 2		Gas								0.025
Cooling   gfnc 1b 5a   389   108   16.3%   \$ 2,801   0   0.02					_				-	0.025
## Page 1					_				-	0.025
Figure   F									-	
Page										0.05
STORY   STOR	S				_					0.1
Second   Part   Part										0.15
Second   Part   Part	1.									
Second   S	seds ion)									0.075
Second   S	- ne ılati							-		
with CAC    State   15 2a   799   75   13.4%   5   3,314   0   0.02	ndo obr						-			0.125
with CAC    State   15 2a   799   75   13.4%   5   3,314   0   0.02	Ноц оf р									0.025
with CAC    State   15 2a   799   75   13.4%   5   3,314   0   0.02	ize 3% (									0.025
Start   Star	m S (83								-	0.025
Start   Star	diu	with CAC		338					0	0.025
Page	Me								0.1	0.05
Heat Pump			gfac 3a 4	431	40	7.1%		530	0.1	0.1
Heat Pump			gfac 4 5a	431	46	7.9%	\$	300	0.1	0.15
Heat Pump			gfac_5b	417	77	11.9%	\$	716	0.1	0.1
Np77 4 5a   1025   0   7.4%   \$   377   0.2   0   0   1.7%   \$   513   0.5   0   0   1.7%   \$   513   0.5   0   0   0   0   0   0   0   0   0			hp85_3b_5a	1054	0	7.6%	\$	77	0.7	0.7
Zonal Resistance Heat		Heat Pump	hp77_2a_4	850	0	6.1%	\$	813	0.1	0.1
State   Stat			hp77_4_5a	1025	0	7.4%	\$	377	0.2	0.2
Resistance Heat    Resistance Heat		Resistance	zonl_1b_2a	239	0	1.7%		513	0.5	0.4
Heat				832	0	6.0%		77	0.5	0.5
State   Stat				1433	0	10.2%	\$		0	0.05
State   Stat										0.05
STOCK   Grace   Stock   Grace   Stock   Stoc								230		0.5
Overall kWh/yr/house Savings 681 66 Overall therms/yr/house Savings 42 4 Overall Total Energy Percent Savings 9.6% 9.8										0.5
Overall kWh/yr/house Savings 681 66 Overall therms/yr/house Savings 42 4 Overall Total Energy Percent Savings 9.6% 9.8	eds   atic							230		0.5
Overall kWh/yr/house Savings 681 66 Overall therms/yr/house Savings 42 4 Overall Total Energy Percent Savings 9.6% 9.8	nee							-		0.5
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Overall kWh/yr/house Savings 681 66 Overall therms/yr/house Savings 42 4 Overall Total Energy Percent Savings 9.6% 9.8										0.2
Overall therms/yr/house Savings 42 4 Overall Total Energy Percent Savings 9.6% 9.8								0.8 <b>669</b>		
Overall Total Energy Percent Savings 9.6% 9.8										44
										9.8%
Uverali Cost   S   678   S   79	Overall Cost						\$ 678	\$ 790		

## **Comparison to Previous Codes**

Figure 1 compares the relative energy use of each of three versions of the WSEC starting with 2006 as the reference year. With each iteration, the code has produced more energy efficient buildings. The estimates of energy use for 2006 and 2009 were based on previous work conducted by Ecotope for NEEA.<sup>1</sup>

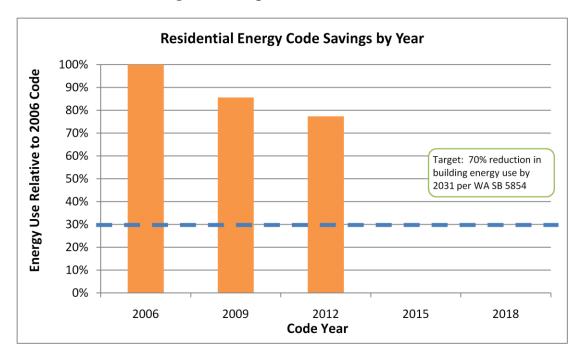


Figure 1. Comparison to Previous Codes

## **Energy Analysis - Simulation Approach**

The analysis approach used is similar to that for analyses of previous WSEC changes by Ecotope and the same methodology approved by the Regional Technical Forum to estimate savings of the proposed 2011 ORSC<sup>2</sup>. Where necessary, it has been adapted to suit the current codes. Broadly, the analysis methodology is to develop a representative set of prototypical houses whose energy use can be estimated through simulation tools. These representative characteristics include climate, occupancy, house size, ground contact type (slab, crawl, or basement), and heating system type.

The building energy use was predicted by a combination of numerical simulations and engineering calculations. SEEM (Simplified Energy and Enthalpy Model) was used to simulate heating, cooling, and ventilation energy use. The program combines building shell characteristics, thermostat settings, occupant behavior inputs, descriptions of heating and cooling systems, and duct distribution efficiency to develop an overall estimate of energy requirements of a house. Additionally, engineering calculations

<sup>1</sup> http://neea.org/docs/reports/2011-residential-codes-energy-use-savings.pdf?sfvrsn=18 http://neea.org/docs/default-document-library/2011-residential-codes-energy-use-savings---appendix-b.xlsx?sfvrsn=8

<sup>&</sup>lt;sup>2</sup> RTF Meeting 9/2010. http://www.nwcouncil.org/energy/rtf/meetings/2010/09/Default.htm

calibrated by field studies were employed to determine the energy use for lighting and water heating. Lighting energy calculations were done using a lighting power density method corresponding to the level of regular and high efficacy lights required by the codes. This method assumes all lamps in the house operate 1.5 hours per day throughout the year<sup>3</sup>. Water heating energy was calibrated to the equivalent of 18 gals per day per occupant<sup>4</sup>. Single family occupancy is 2.5 people/house. The loads not regulated by the code, including appliances and plug loads are assigned a constant value of 4,000 kWh/yr for both the 2009 and 2012 codes.

SEEM (version 0.94), the residential energy-simulation program used for the analysis was developed by and for the Northwest Power and Conservation Council and the Northwest Energy Efficiency Alliance (NEEA), and written by Larry Palmiter of Ecotope. It is the simulation engine used to provide heating and cooling energy savings estimates for the residential sector in the Northwest Power Plan, for the Performance Tested Comfort System (PTCS) incentive program, as well as numerous other utility program offerings. SEEM is also used extensively to support state building energy code revisions including, most recently, the revised Washington State Energy Code and Oregon Residential Specialty Code.

The SEEM program consists of an hourly thermal, moisture (humidity), and infiltration simulation that interact with ducts, equipment, building shell and weather parameters to calculate the space conditioning requirements of the building. It is based on algorithms consistent with current American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), American Heating and Refrigeration Institute (AHRI), and International Organization for Standards (ISO) calculation standards. The simulation generates outputs used in this analysis; they include building heat loss (UA), heating equipment input energy, cooling equipment input energy, and ventilation equipment input energy.

The weather files used in all savings simulations include Seattle for IECC zone 4 marine and Spokane for IECC zone 5.

Three distinct building prototypes were used in the SEEM simulations: a 1344 ft<sup>2</sup> (square foot) ranch style home, a 2200 ft<sup>2</sup> split level home, and a 2688 ft<sup>2</sup> home with a full conditioned basement. These are standard analytical prototypes used by the Northwest Power and Conservation Council to develop and evaluate energy forecasts and conservation plans for the region's utilities.

The 1344 ft² and 2200 ft² prototypes are split further into crawl space or slab-on-grade construction. Next, each prototype is assigned a weight in proportion to its frequency of occurrence in the building population. By creating a weighted average of prototypes, a single estimate is made to represent the energy use of constructing a new house in a Washington. Accounting for the different ground contact possibilities there are five prototypes used to describe the single family house (1344 crawl and slab, 2200 crawl and slab, 2688 basement).

<sup>&</sup>lt;sup>3</sup> RTF Meeting 9/2010: http://www.nwcouncil.org/energy/rtf/meetings/2010/09/Default.htm

<sup>&</sup>lt;sup>4</sup> RTF provisionally approved savings measure: http://www.nwcouncil.org/energy/rtf/measures/measure.asp?id=176